Maine Agricultural Experiment Station

BULLETIN No. 68. OCTOBER, 1900.

EXPERIMENTS WITH INSECTICIDES UPON POTATOES.

This Bulletin contains the results of spraying experiments for the potato beetle with Paris Green, Paragrene, four Arsenoids, and Arsenate of Lead, including Disparene and Boxal; and a field and green house test of Bug Death as an insecticide.

Requests for the Bulletins should be addressed to the

EXPERIMENT STATION,

Orono, Maine.

MAINE

AGRICULTURAL EXPERIMENT STATION

ORONO, MAINE.

THE STATION COUNCIL.

PRESIDENT ABRAM W. HARRIS	*President*
DIRECTOR CHARLES D. WOODS	*Secretary*
EDWARD B. WINSLOW, Portland	*Committee of Board of Trustees*
VORANUS C. COFFIN, Harrington	*Committee of Board of Trustees*
JOHN A. ROBERTS, Norway	*Committee of Board of Trustees*
B. WALKER MCKEEN, Fryeburg	*State Board of Agriculture*
EUGENE HARVEY LIBBEY, Auburn	*State Grange*
CHARLES S. POPE, Manchester	*State Pomological Society*
JAMES M. BARTLETT	*Members of the Station Staff*
LUCIUS H. MERRILL	*Members of the Station Staff*
FREMONT L. RUSSELL	*Members of the Station Staff*
WELTON M. MUNSON	*Members of the Station Staff*
GILBERT M. GOWELL	*Members of the Station Staff*
GILMAN A. DREW	*Members of the Station Staff*

THE STATION STAFF.

THE PRESIDENT OF THE UNIVERSITY.

CHARLES D. WOODS	*Director*
JAMES M. BARTLETT	*Chemist*
LUCIUS H. MERRILL	*Chemist*
FREMONT L. RUSSELL	*Veterinarian*
WELTON M. MUNSON	*Horticulturist*
GILBERT M. GOWELL	*Stock Breeding and Poultry*
GILMAN A. DREW	*Entomologist*
LUCIUS J. SHEPARD	*Assistant in Agriculture*
ORA W. KNIGHT	*Assistant Chemist*
EDWARD R. MANSFIELD	*Assistant Chemist*
CLIFFORD D. HOLLEY	*Assistant Chemist*

EXPERIMENTS WITH INSECTICIDES UPON POTATOES.

CHAS. D. WOODS.

Through the generous coöperation of Mr. John Watson of Houlton the Station has been able to make under exceedingly favorable conditions field experiments upon the potato. Not only did Mr. Watson give the free use of land, but he also furnished the labor and machinery. The management of the Bangor and Aroostook Railroad, with their characteristic interest in and support of all that has for its aim the improvement and development of Aroostook county, furnished free passenger transportation to a large amount. Because of this help the Station was enabled to make a series of experiments which it could not otherwise have undertaken.

Experiments as follows have been carried to a successful issue:

1. A soil test experiment of 25 plots.

2. An experiment of 25 plots on the effect of fertilizers, particularly different potash salts, upon the starch content of the potato.

3. A spraying experiment with Bordeaux mixture and other fungicides for potato blight.

4. An experiment with several commercial insecticides in comparison with Paris green as a remedy for the potato beetle.

The experiments with insecticides are here reported. The others will be prepared for publication as early as practicable.

For the experiment with insecticides, Mr. Watson kindly placed a ten acre field of fairly uniform slope and soil at our disposal.

This field was planted with Green Mountain potatoes late in April, the rows running east and west. There were 224 rows about 30 rods long running across the field, and in addition about 20 shorter rows at the north and ten at the south ends of the

field. The piece was divided in this way into 14 plots of 16 rows each with 2 plots of shorter rows at either end. The short rows were untreated except that Paris green and whitewash were sprayed on these July 27th so as to kill most of the bugs. The arrangement of the plots and their treatment is shown in the following plan:

ARRANGEMENT OF PLOTS.

Each plot consisted of 16 rows about 30 rods long. The rows ran east and west. Row 1 at north end.

No. of rows.	Kinds of Insecticides.	Rate per acre at each application.
		Pounds.
1 to 17	Paris green	½
17 to 32	Boxal (arsenate of lead as the poison)	5
33 to 48	Boxal (arsenate of lead as the poison)	10
49 to 64	Paris green	½
65 to 80	Paragrene	½
81 to 96	Paris green	½
97 to 112	Swift's arsenate of lead	1
113 to 128	Arsenoid No. 2	½
129 to 144	Paris green	½
145 to 160	Arsenoid No. 3	½
161 to 176	Paris green	½
177 to 192	Arsenoid No. 4	½
193 to 208	Arsenoid No. 5	½
209 to 224	Paris green	½

DATES OF APPLICATION.

The insecticides were applied under the immediate oversight of the writer, with water together with a fungicide, either Bordeaux mixture, or other similar materials, in the form of a fine spray at the folowing dates:

July 11, rows 1 to 128; July 13, rows 129 to 224; July 21, rows 1 to 224; July 27, rows 1 to 224; August 10, rows 1 to 112, and August 11, rows 113 to 224.

The experiment was visited by the writer at least once a week during the growing season, and two or three days after each application each plot was carefully examined and full notes taken.

THE APPLICATION OF PARIS GREEN AND OTHER POWDERED INSECTICIDES.

When Paris green was first used for the potato beetle it seems to have been applied dry. This was probably partly due to the difficulty of transporting the water and partly (and perhaps more especially) to the imperfect distribution which resulted from sprinkling the plants with watering cans. Since the introduction of improved spraying machinery, the poisons can be more evenly and effectively distributed with water than by dusting.

None of the poisonous powders are dissolved in the water but are mixed with it and held suspended. The heavier the powder and the coarser the particles the greater will be the tendency for it to settle in it. An efficient agitator is an indespensible part of a spraying outfit. The materials are best applied as a fine spray, as in this way the whole plant can be readily covered and practically none of the solution runs off the foliage. In the case of the copper compounds of arsenic, freshly slacked lime should be added to the water at the rate of 2 pounds to barrel.* This will make the Paris green, etc., adhere better and effectually prevent burning the foliage. Half a pound of good, finely pulverized Paris green can be sprayed on so as to be more effective than a much larger amount applied with a "gun" or other dusting devices. It can also be applied much faster and with less labor. One man with a 4-rowed mechanical sprayer can readily treat 20 acres a day, and 30 acres with a 6-rowed sprayer.

In the experiments here reported upon, the poisons were all applied with a four-rowed mechanical sprayer fitted with a powerful hand pump. As it was desired to take every precaution for thorough spraying, two men were on the cart, one to pump, the other to drive and watch that the nozzles did not get stopped. In the first spraying one Vermorel nozzle was over each row and the rows were gone over twice in opposite directions. The other three applications were made with a double Vermorel nozzle. A barrel of spraying materials with two single or one double nozzle for each row will spray an acre. Some power mechanical sprayers, such as the Aspinwall, do not have

*In case the plants are sprayed with Bordeaux mixture at the same time, the addition of the lime is not necessary.

a sufficiently powerful pump to use double nozzles, and on this account are not well adapted to practical spraying in a potato growing district.

RESULTS WITH INSECTICIDES.

While experiments at this time included only Paris green, arsenate of lead, Paragrene and the arsenoids, notes are here given on other insecticides which are used to a greater or less extent in the State.

PARIS GREEN.

Since the advent of the Colorado potato beetle, Paris green has been the favorite and indeed practically the only insecticide used. According to the U. S. Dispensatory, Paris green is the aceto-arsenite of copper and "is made by mixing 5 parts of verdigris with sufficient water to form a thin paste, and adding to this a boiling solution of 4 parts of arsenious acid in 50 parts of water, keeping the mixture at the boiling temperature and adding a little acetic acid to cause it to retain a brilliant color." The pure aceto-arsenite of copper should carry 58.65 per cent of arsenious oxide. There is also another compound sometimes sold under the name of Paris green which is practically the arsenite of copper and theoretically carries 52.94 per cent of arsenious oxide. (See arsenoids beyond.)

Formerly Paris green was used only as a pigment and the first aim of the manufacturer was to produce a good bright green. Since its use as an insecticide the consumption has greatly increased and different manufacturers have modified the process of manufacture so that in many instances they differ quite widely from that outlined above. In at least one plant the green is made from copper oxide, arsenious acid, and a soluble acetate. The ingredients used will always contain varying amounts of impurities and on this account very little, if any, Paris green is strictly pure aceto-arsenite of copper. As the arsenious acid is the cheapest single constituent, the claim made by one manufacturer that "as long as the green is pure, the manufacturer will endeavor to get as much arsenic into it as possible, consistent with making a good bright green," is probably true. So-called "pure" Paris greens which do not bear evidence of adulteration have been found to carry as little as 47 per cent of arsenious acid and others

have carried as high as 68 per cent. In the case of the goods with the low percentage, the relatively small amount of arsenic is due to impurities of the materials. In the case of green carrying more than 58.5 per cent of arsenious acid, the higher arsenic content can only be explained by their having an excess of uncombined arsenious acid (white arsenic). As white arsenic burns foliage much more than does Paris green, or even London purple, its presence in Paris green is objectionable. The purity of a Paris green is not necessarily indicated by its arsenic content since an excess of uncombined white arsenic is nearly as dangerous an adulterant as the presence of inert foreign matter. When pure, Paris green should have at least 50 per cent of arsenious oxide and should be practically free from uncombined arsenic. Important as the purity of the green is, its mechanical condition is of great moment. To thoroughly protect the plant it is necessary that the poison be thoroughly distributed. It follows therefore that of two equally pure greens, the one that is in the finer powder will prove the more effective. In our experience there is greater danger of purchasing imperfectly pulverized, than adulterated Paris green.

The purity of Paris green can be quite readily and fairly accurately tested by dissolving the Paris green in strong ammonia water. If pure all of the Paris green will dissolve, the solution turning a deep blue color. Undissolved sediment indicates impurities or adulteration. Another test is to place a little of the Paris green between two pieces of window glass and rub them together. If the Paris green is adulterated with lime, barium sulphate, or similar white materials, the Paris green will appear to turn white in places. Paris green of good quality is intensely bright green and uniform. When adulterated, the green loses something of its intensity and is grayish green and is not always uniform.

In the experiments here reported upon, Paris green was used in connection with some form of Bordeaux mixture in all of the check plots.

The Paris green was applied at the rate of one-half pound to the acre. The first application was made before any of the eggs had hatched and may have been unnecessary. The three applications of Paris green at the rate of one-half pound to the acre

kept the bugs so reduced in numbers that they did no appreciable damage to the vines, and the fourth application (August 10-11) was unnecessary. The green was as usual somewhat difficult to keep thoroughly and evenly suspended in the water. When applied with lime at the rate of ½ pound of Paris green and two pounds of lime to the acre, the Paris green was more effective than when applied at the same rate with copper, (Bordeaux mixture). The copper appeared to be distasteful to the bugs and they would leave the thoroughly sprayed leaves for those that had less copper and in this way they avoided the leaves with the most Paris green. If vines are sprayed before the bugs have made much growth, there is no difficulty in keeping them in check, so they can do no harm, with two or three applications of Paris green at the rate of ½ pound to the acre. Applied at this rate with Bordeaux mixture or lime, there is no danger of burning the foliage.

LONDON PURPLE.

London purple was first introduced in this country as an insecticide in 1877. It is a waste product in the manufacture of some dye stuffs and consists largely of arsenic, lime and the dye. It is cheaper than Paris green, contains more arsenic and can be more easily applied.

Its composition is not so uniform, and it is more apt to injure foliage so that on the whole Paris green has been preferred. It was not used in the experiments here reported upon. Paris purple and English purple are two preparations quite similar in character to London purple. When any of the purples are used as insecticides they should be used with two or three times their weight of lime because of the soluble arsenic which they contain.

PARAGRENE.

Paragrene is a patented article which claims to be free from many of the objectionable features of Paris green. The manufacturers state that "Paragrene is a definite compound of arsenic, sulphate of copper and lime and is made in such a way as to neutralize whatever effect the acids, necessary to prepare the ingredients, would have on plant life." It has recently been analyzed by the California Agricultural Experiment Station and found to contain 23.46 per cent of copper oxide and 40.60

per cent of arsenious oxide, 23.08 per cent of which is free. It also contains 19.31 per cent of gypsum to add weight. Because of its large amount of free arsenious oxide it would be apt to burn the foliage of tender plants. On such a plant as the potato and in the small quantity used mixed with lime or Bordeaux mixture, the burning by this amount of free arsenic would not be likely to be great. It was applied four time with Bordeaux mixture at the rate of one-half pound per acre to rows 65 to 80. The field notes follow.

July 11, potatoes just beginning to bloom, no slugs hatched yet, sprayed; July 21, sprayed; July 24, very few bugs, none on coated or eaten leaves; July 27, sprayed; August 1, practically no bugs; August 8, practically no bugs; August 10, sprayed; August 14, no bugs; August 23, a few leaves are browned and curled on *edges;* no spots as in blight; appear to be slightly burned; September 4, the "burning" has made no progress.

The Paragrene used in this experiment was coarser than Paris green and when wet up with water there was quite a little residue left that would not go through a fine Vermorel nozzle. The attention of the company was called to the coarseness of the sample we used and in explanation they write as follows: "This is no doubt due to the rent or tear in the mill in which it is bolted. Sometimes this is bound to occur and a lot will go through the bolter before it is discovered, but we can assure you it is only an accident and instead of being coarse and gritty, the goods are always as fine as it is possible to get the best grade of flour."

In this experiment Paragrene proved as effective as Paris green and in the amount used did not burn the foliage so as to injure it, if at all.

ARSENOIDS.

Under the general name arsenoids quite a number of different arsenites have been placed upon the market. White arsenoid was supposed to be barium arsenite, but all of its arsenious acid was free so that it was no better than white arsenic diluted with baryta. Pink arsenoid is arsenite (not arsenate) of lead. A sample examined by the California Station* carried 40 per cent of combined and 3¼ per cent of free arsenious acid. The green

* Bulletin No. 126.

arsenoid or arsenite of copper has been quite extensively introduced by the Adler Color and Chemical Works. A sample examined by the California Station was found to carry 53½ per cent of combined and nearly 8 per cent of free arsenious oxide. As previously stated, copper arsenite if pure would carry about 53 per cent of combined arsenious oxide.

The Adler Color and Chemical Works are experimenting with different arsenoids with the hope of obtaining compounds which will be as effective and at the same time cheaper than Paris green. Four of these materials called Arsenoids Nos. 2, 3, 4, and 5 were used in these experiments. In each case they were applied four times with Bordeaux mixture at the rate of one-half pound of arsenoid to the acre.

The manufacturers make the following statements to us relative to these materials.

"No. 2 arsenoid is a compound containing arsenious acid, copper and lime and is made by treating arsenite of soda with sulphate of copper and lime. This gives an absolutely neutral combination of salts which is not likely to do any damage to foliage even when used in very strong solution. Could be sold for about 8 cents per pound. We have hopes that this will prove in every respect a most desirable insecticide.

"No. 3 arsenoid is made by treating a solution of acetate of lead with arsenate of soda and at the same time making an admixture of arsenite of copper. Cost of this would be about 14 cents per pound.

"No. 4 arsenoid is made by precipitating acetate of lead with arsenate of soda and at the same time adding arsenite of soda precipitated with lime, along with an admixture of arsenite of copper. The resulting compound consists of arsenite of lead, arsenite of lime and some arsenite of copper. This could be sold for about 10 cents per pound.

"No. 5 arsenoid is made by precipitating arsenite of soda with sulphate of copper and lime, producing an arsenite of copper and lime. This could be sold for about 10 cents per pound."

There was not much difference to be seen in the way the different arsenoids acted. None of them at the rate used burned the foliage and they all killed the bugs practically as well as Paris green. The arsenoids are more bulky and on this account are

more readily kept in suspension than Paris green. The field notes show the arsenoids to have been about as effective as Paris green but not so effective as the arsenate of lead. While they may contain more free (uncombined) arsenious acid than the best made Paris greens, they probably contain no more than the average Paris green. There is little reason for using them instead of Paris green unless they can be had at a considerable lower price.

ARSENATE OF LEAD.

The Massachusetts Gypsy Moth Commission have during the past ten years made exhaustive comparative studies of different arsenical compounds as insecticides. In 1893 Mr. F. C. Moulton, a graduate of the Chemical Course of the University of Maine, was employed by the commission and suggested the use of arsenate of lead as an insecticide. It was found to be "the most effective poison yet used" and for the last year or two of the commission it was employed almost exclusively. The findings of the commission are summarized as follows:*

"Although nearly all poisons known to us which can be used as insecticides have been experimented with during the past five years in the hope that something would be found which would prove fatal to the gypsy moth, only one which is more effective than Paris green has been discovered. This is arsenate of lead, a poison slower in its action than the other, but which has three distinct advantages: (1) It can be used at any desired strength without serious injury to the foliage; (2) It is visible wherever used, as it forms a whitish coating on the leaves; (3) It has adhesive qualities, given it, probably, by the acetate of lead, and therefore remains on the leaves for a much longer period than Paris green. When sufficient glucose was added to a strong mixture of arsenate of lead, it withstood rainstorms and remained on the foliage during an entire season."

The arsenate of lead used by the commission was prepared, for the most part, by using 30 parts of arsenate of soda and 70 parts of acetate of lead. Prof. C. H. Fernald directs that arsenate of lead can be prepared in the proportions of 11 ounces of acetate of lead, and four ounces of arsenate of soda. The materials are

*The Gypsy Moth, Forbush and Fernald published by the Massachusetts Board of Agriculture, pages 141 and 142.

dissolved separately in water and slowly poured together with stirring.

Arsenate of lead is made by William H. Swift & Company, Boston, Mass., and the Bowker Chemical Company also of Boston. The latter company sell the goods under the name of Disparene. The chemist of one of the companies was for several years with the Gypsy Moth Commission and while with them constantly urged farmers to make arsenate of lead by the above formula and use it as an insecticide. Because of this we asked him why he now recommends the consumer to buy the "ready made" instead of using "home made" arsenate of lead. His reply (in part) is as follows:

"Between the years 1896 and 1899 Prof. C. H. Fernald and I, as opportunity offered, preached faithfully the gospel of home made arsenate of lead to our fruit growers and farmers. We had to do this. There was no one making it. As a result of these continued efforts not more than 15 or 20 farmers tried it. Most of them found it too expensive; many of them injured their foliage because of poor chemicals, wrong formula or improper mixing.

"The objections to the use of the home made article are the difficulties attending its manufacture. The more important are:

"To obtain arsenate of soda free from adulteration. In our experience in the gypsy moth work we were greatly bothered with adulterated arsenate of soda. Made as it generally is, by the use of rock salt, there is more or less of the latter left in the arsenate of soda. When mixed with a solution of lead salts, the sodium chloride acts first, forming lead chloride, which has no value as an insecticide; later, the arsenate of soda reacts, but often there is not lead enough allowed for the complete neutralizing of the latter. This leaves soluble arsenic in the mixture and "burned" foliage results. We went over the ground fully in our gypsy moth work and finally had to import arsenate of soda from England in order to get a pure article.

"The establishing a correct formula. Commercial arsenates of soda vary from 50 per cent to 98 per cent in purity. The ordinary formula, 11 ounces sugar of lead to 4 ounces arsenate of soda applies to the 50 per cent article. For the 65 per cent, less arsenate of lead must be taken; for the 98 per cent, still less.

The farmer must know the grade of goods he is working with and establish a new formula with each change of percentage."

The experience of the other company is practically the same. In answer to the question why ready made was superior to home made arsenate of lead, they said (in part) as follows:

"In regard to your inquiries regarding the manufacture of arsenate of lead, would say that it is made from arsenate of soda with either acetate or nitrate of lead. Each salt is dissolved separately, filtered and the solutions added together, when arsenate of lead precipitates out chemically. It is very necessary to have exactly the right proportions of the two salts, as an excess of either (particularly the arsenate of soda) will burn the foliage. As commercial arsenate of soda runs from 50 per cent to 68 per cent arsenious acid and acetate of lead varies somewhat, the correct proportions cannot be obtained without a chemical analysis.

"The remarkable adhesiveness of arsenate of lead is principally due to the extreme fineness of the particles in the precipitate. This we have been able to obtain only by a great many experiments to find the right conditions.

"Both arsenate of soda and acetate of lead are deadly poisons, and would be much more dangerous to have around than a disinfectant plainly marked, and understood to be poisonous.

"Taking all these facts into consideration, in our opinion the making and use of arsenate of lead by persons without a chemical knowledge would be dangerous and unsatisfactory."

While both of these companies have made the difficulties of preparation fully as great as they really are, there is no doubt that the average man had far better buy prepared arsenate of lead than attempt its manufacture.

As sold, arsenate of lead (including disparene) is put up in paste form, and carries from 60 to 70 per cent of arsenate of lead.

In the experiments here reported upon Swift's arsenate of lead and Bowker's boxal (in which the poison is lead arsenate) were used. Disparene was sent, but it was received too late to be used for the first spraying.

Swift's arsenate of lead. Rows 97 to 112 were treated four times with Bordeaux mixture and Swift's arsenate of lead at the rate of one pound to the acre. The field notes are as follows:

July 11, potatoes beginning to bloom, no slugs hatched yet, sprayed; July 21, sprayed; July 24, practically no bugs, less than on any other plants; July 27, sprayed; August 1, with the exception of three hills the north side of which was missed in spraying, only two bugs were seen in the whole length (30 rods) of 4 rows; August 8, practically free from bugs; August 10, sprayed, it began to sprinkle as this was being applied, only a light shower, but did not clear off; August 14, no bugs.

Boxal as an Insecticide. Boxal is a "concentrated Bordeaux mixture, reenforced with copper hydrate for the prevention of blight and sufficient arsenic for killing leaf-eating insects." The arsenic is in the form of arsenate of lead. It was applied in these experiments four times at the rate of 5 pounds, and in another plot at the rate of 10 pounds of boxal to the acre. The field notes are as follows:

Rows 17-32, boxal at the rate of five pounds to the acre. July 11, potatoes just beginning to bloom, no slugs hatched yet, sprayed; July 21, sprayed; July 24, bugs more numerous than on rows 1-16 (Paris green) but no badly eaten plants; July 27, sprayed; August 1, bugs less than on rows 1-16 (sprayed with Paris green); August 8, a few bugs, about the same as on rows 1 to 16; August 10, sprayed; August 14, very few bugs,—none except on here and there a plant.

Rows 33 to 48. Boxal at the rate of 10 pounds to the acre. July 11, potatoes just beginning to bloom, no slugs hatched yet, sprayed; July 21, sprayed; July 24, bugs about the same as on rows 1 to 16, no living bugs on eaten leaves; July 27, sprayed; August 1, very few bugs and then only on occasional hills, no need of further spraying for bugs; August 8, practically no bugs; August 10, sprayed; August 14, no bugs.

In this experiment spraying four times with boxal at the rate of five pounds to the acre and three times at the rate of ten pounds to the acre kept the bugs from doing any damage. The larger application was the more effective.

Disparene. Disparene is a paste of arsenate of lead and "contains from 62 to 68 per cent of arsenate of lead." As previously stated it was received too late to be used in the experiment. It was however applied to a piece of 3 or 4 acres which had been sprayed twice with Paris green without killing off the bugs as

much as was desirable. The spraying with disparene was effective and cleared the field from bugs.

Disparene was used by several farmers in the vicinity of Houlton and, in some instances, the results were not satisfactory. From our experience with arsenate of lead the trouble would seem to be in the application rather than in the poison itself.

SUMMARY.

Arsenate of lead was used at the rate of one pound to the acre and in the case of boxal much less than that. It is very readily mixed with water and stays in suspension so that it is possible to apply it much more evenly than Paris green. It adheres well to the foliage and is the most effective of any of the insecticides tried.

BUG DEATH.

The Danforth Chemical Company of Leominster, Mass., have put upon the market a preparation for which they make great claims and for whose merits some users fail to find language too strong in which to extol the goods. The advertising circular of 1900 says:

"The farmers who used Bug Death freely the past season on potatoes had a large crop of good smooth potatoes that actually brought a higher price in the market than those of their brother farmers who did not use Bug Death, but who did use some of the many insecticides that contain arsenic.

"Why should you feed your crops on a deadly poison? Is it not better to feed them with something that is a plant food, as well as an insecticide, thus freeing the plant of the insects and promoting growth, which increases yield and improves quality, especially when blight is prevalent? If used according to directions the extra yield will more than pay the entire expense.

"If you have made a test of it we rest assured that you will be a permanent customer. If to you it is new or unheard of we ask that you read these testimonials which, coming as they do from prominent dealers (all of whom are well and favorably known to the people of their respective states), will, we are sure, induce you to at least give Bug Death a trial, and then we are confident that the practical results derived from its use will convince you of its merits."

Following this are a large number of testimonials from dealers and others of the wonderful results which followed the use of Bug Death in 1899.

This Station has not made an analysis of Bug Death but it was analyzed by the N. Y. (Cornell) Station in 1898 and found to consist of zinc oxide 76.5 per cent, lead oxide 9.8 per cent, iron oxide 7.8 per cent, small amounts of silica, chlorine, potash and a trace of phosphoric acid.

In May we wrote the Danforth Manufacturing Company, as we did all other manufacturers whose goods we proposed testing in the field and received a letter from the superintendent saying: "We are desirous of having our good tested this year." He stated that he was to be in Maine in the near future and that he would call and talk the matter over. The latter part of June he called at the Station. The interview was a pleasant one and while we expressed doubts as to the goods doing what was claimed for them, the whole experiment was explained to the superintendent and he went away saying that personally he would like to have the trial made but that he would have to consult with his associates. Under date of June 26th he wrote as follows: "The writer has conversed with other members of our firm in regard to entering the competition test at Houlton, and we have decided not to go into it this year."

After the spraying experiment was well under way we learned more as to the large sales of Bug Death that were being made in Maine and decided to give the goods a trial. Near the large experimental field was a small plot (about ¼ of an acre) used by the former owner of the place as a garden which was planted to Green Mountain potatoes. About half of it was treated with Black Death and later with Paris green and the remainder with Bug Death.

The directions for application of Bug Death are as follows:

"For potato and other plants or vines which require a top application, apply dry with Perfection shaker at the rate of 12½ pounds or more per acre to an application, acording to size and condition of the vines. Dust the plants thoroughly and pleasing results will follow."

THE FIELD NOTES ARE AS FOLLOWS:

July 23, five pounds of Bug Death (at the rate of 40 pounds per acre) applied. Bugs in all stages of growth, but not very numerous.

July 24, bugs not very numerous but apparently happy. Many feeding on eaten plants and no signs of disturbance and no dead ones on the ground. Diligent search failed to show a single dead beetle or slug or a badly eaten plant cleared. Five pounds more (a total of 80 pounds per acre) applied.

July 25, heavy rain.

July 27, bugs numerous. Decided to give up use of Bug Death but the superintendent of the Danforth Chemical Company arrived before the plot was treated with Paris green, and at his desire the piece was treated with one package (12½ pounds) or at the rate of 100 pounds per acre. This was applied with the Perfection shaker and it took one man a little less than an hour and a half to apply it.

August 1, bugs practically all gone. No dead ones to be seen. A few leaves that look as though they had been burned. There was a heavy shower last night and the Bug Death appears to be practically all washed off.

August 7, practically no bugs.

August 14, some bugs but less than on the part treated (one application, July 27) with Paris green. The edges of some leaves, especially at east end, are brown. It does not look like blight but more as if they had been burned.

August 18, blight beginning to appear but considerably less than on other part of piece. Burned leaves are more conspicuous than on the 14th.

August 23, burned leaves still more conspicuous, chiefly at east end. Some bugs and blight but not nearly as many or as much as on other part of the piece.

August 31, pretty generally affected with blight, although not so bad as other part. The so-called burned leaves are practically all dead. They died from the margin of the leaf towards the center. Very different from the way that the other plants have acted with blight.

September 4, much the same as on August 31. Blight still making some progress.

September 7, heavy frost which practically put an end to growth.

That there might be no confusion between the action of the Paris green and the Bug Death, two unsprayed rows were left between the two parts of the piece. On August 1 it was noticed that these two rows were badly infested with slugs and beetles, and that there were very few bugs on the part sprayed with Paris green. In the light of the experiments in the greenhouse, described beyond, the great number of bugs on these untreated rows was probably due to their being driven by the Bug Death.

EXPERIMENTS WITH BUG DEATH IN THE GREENHOUSE.

The heavy application (at the rate of 100 pounds to the acre) cleared the vines to which it was applied from bugs. Practically no dead bugs were found in the field and the superintendent of the company said that they very seldom found dead bugs under the plants, but that it cleared the vines when applied in sufficient quantities. In order to observe the effect of the Bug Death more carefully and accurately than is possible in a field test, potato plants were transplanted into the greenhouse in pots and the following experiments made, under the oversight of LeRoy H. Harvey.

The experiments with Bug Death were carried on as four distinct experiments. The potato plants were divided into four groups; each group being separated from the others and enclosed by mosquito netting. The treatment of each group and the observed results follow. The treatment began at 10 A. M.

FIRST EXPERIMENT.

Statement of Conditions. Three plants were taken. One plant was thoroughly covered with potato slugs, and they were allowed to remain unmolested until they were feeding freely. Then a liberal quantity of Bug Death was uniformly dusted over the plant with the slugs.

Results: Within half an hour after the application, the slugs were noticed to be crawling onto the underside of the dusted leaves which were free from the Bug Death.

After 6 hours a few of the slugs had left the treated plant and crossed over to undusted ones, and in so doing were obliged to climb over a piece of pasteboard 6 inches high which separated the undusted from the dusted plants. On the ground under the dusted plant were observed 3 dead slugs.

After 22 hours a few more were found dead under the dusted plant. More than half of the slugs had been driven from the plants even forcing themselves out from under the netting. In their eagerness to get away they left the plants which were free from the Bug Death. Clinging to the leaves of the dusted plant were a few slugs which on being touched fell to the ground. Although apparently alive, they were dead.

After 28 hours not much change was noticed, except a few more driven and the remaining ones were apparently in a sort of stupor.

After 52 hours all the slugs were driven from the upper part of stalks. A few were observed apparently feeding at the base of the plants.

After 68 hours about a third of the remaining few had crossed over to the undusted plants. Those remaining on the treated plant were eating heartily on the lower leaves, which had not been reached in the dusting. No stupor was noticeable.

The plants were allowed to remain several days after the sixth observation, but nothing further of note was observed.

SECOND EXPERIMENT.

Statement of Conditions. In this experiment three plants were also taken. One plant was dusted as well and evenly as possible and then covered with the slugs.

Results: The slugs almost immeditely and collectively sought the underside of the treated leaves.

After 6 hours several of the slugs were observed on the undusted plants to get to which they must have, as in No. 1, climbed over a strip of pasteboard 6 inches high separating the dusted from the undusted plants. Five slugs had succumbed to the Bug Death.

After 22 hours nearly three-fifths of the slugs had been driven from the treated plant forcing themselves under the netting and

escaping, as in No. 1, in preference to going on to the untreated plants. A few dead slugs were seen clinging to the branches.

After 28 hours there was a slight increase in the number of dead. The same semi-stupor apparent in the corresponding observation in No. 1 was here also evident.

After 52 hours a few more bugs had left the treated and crossed over to the undusted plants.

After 68 hours only a few bugs were remaining and these were eating heartily on the basal leaves, the stupor apparently having passed away.

Nothing of importance was observed in the following three days at the end of which time the experiment was discontinued.

THIRD EXPERIMENT.

Statement of Conditions. The four plants which were taken in this group were all first thoroughly wet with water, then liberally sprinkled with Bug Death. The operation was repeated, first wetting and then sprinkling, until the leaves were evenly covered with Bug Death, and there was no dust apparent as such. The plants were next freely covered with slugs.

Results: As in experiments Nos. 1 and 2 the slugs soon sought the underside of the leaves.

After 6 hours a few of the slugs were noticed making their escape from under the netting and four were found dead under the plants.

After 22 hours there were a few more dead under the plants. There was a general leaving of the upper leaves for the basal. Almost half of the insects were driven as in previous experiments.

After 28 hours no marked change was noticed. A few more bugs had gone to the base of the leaves, and the semi-stupified condition was becoming evident.

After 52 hours there were only a few slugs left on the vines, the others apparently have been driven away.

After 68 hours the few remaining bugs were feeding freely on the basal leaves. The semi-stupor was not apparent.

During next three days no change was observed and the experiment was discontinued.

FOURTH EXPERIMENT.

Statement of Conditions. This experiment differed from No. 1 only in that *all* the plants were first covered with slugs and then very liberally dusted with Bug Death.

Results: As in the three preceding experiments the slugs as soon as dusted started for the under side of the leaves and within an hour not a slug was left on the surface of the leaves.

After 6 hours a few dead slugs were found under the plants. Several had already started to escape.

After 22 hours several more dead slugs were found under the plants. Nearly one-half of the slugs had made good their escape by forcing themselves under the netting.

After 28 hours the number of the remaining slugs was somewhat decreased. The semi-stupor noticed in the corresponding observations of experiments Nos. 1, 2, 3, was also here slightly noticeable.

After 52 hours no change was noticeable. The few remaining slugs were feeding on the under side of the lower leaves.

After 68 hours only two slugs were remaining on the plants, and these were feeding on the basal leaves. The slugs showed no sign of any stupor.

During the three following days no observation worthy of record was made and so the experiment was discontinued.

Summary of the results. The effect most noticeable upon the bugs from the application of the Bug Death is its great driving property. The principle exodus of the slugs took place during the first night, and the subsequent escapings were also mostly made at night.

In the four experiments in the observations which took place after 28 hours, a semi-stupified condition was quite noticeable. The slugs would hang onto the under side of the leaves slightly curled up, apparently dead. When knocked to the ground they would slowly uncurl themselves and perhaps in an hour or so would be back again on the plants or more likely they would have made their escape under the netting. During the next forty-five hours there was an apparently complete recovery from the stupefaction. Only a small number of slugs were killed by the Bug Death. Whether these were killed by suffocation from the appli-

cation of the powder or from being poisoned by eating the Bug Death, the experiments do not conclusively show. In the third experiment the death rate was about as in the other trials and here the attempt was made to get rid of the dust by wetting. Whatever value the material has is dependent upon the strong dislike which the bugs show for it, rather than to any insecticidal qualities which it may have.

THE COST OF BUG DEATH.

The price as advertised ranges from 15 cents for a single pound to 8 cents in the largest package which the company puts out. At the rate applied in these experiments it would cost $8.00 per acre for the material for each application. Two applications a fortnight apart would be needed to keep the potatoes free from bugs. When applied to vines not covering the ground an application at the rate of 40 pounds per acre was without effect, so it would seem that the second application must be as great as the first. To partly protect would cost for the Bug Death $8.00 per acre while to thoroughly protect against bugs would cost $16.00 for materials. The "Perfection Shaker" is a covered tin dish with small holes in the bottom. Applied with this shaker a man would be kept very busy and might develop a lame wrist in the attempt to apply 100 pounds in one day. In Aroostook county there are in the neighborhood of 25,000 acres of potatoes on which the bugs must be killed within a few days time. In the presidential election of 1896 the county polled 6,472 votes. It would take ten days for these voters to protect the potato plants from bugs applying Bug Death with the Perfection shaker. A farmer growing 20 to 50 acres would find it impossible to get the help necessary to apply Bug Death at the right time.

One pound of Paris green, or other arsenites applied at two different times will do all the work of 200 pounds of Bug Death. The Paris green can be applied with power sprayer at the rate of 20 to 30 acres a day, and a thorough application of Bordeaux mixture can be applied at the same time with only the added cost of materials (about 40 to 45 cents an acre). Reckoning a man's time at 15 cents an hour it would cost at least for materials and labor 18 dollars an acre to apply Bug Death twice. For two dollars and a half an acre can be treated four times with Bordeaux mixture and a reliable poison.

SUMMARY.

It is claimed for Bug Death that it acts as an insecticide, fungicide and fertilizer.

Bug Death is chiefly zinc oxide. It contains no nitrogen, a mere trace of phosphoric acid and a small amount of potash.

As an insecticide.

At the rate 100 pounds per acre it freed potato vines from bugs.

At the rate of 40 pounds per acre it had no appreciable effect.

Bug Death drives the bugs and makes them leave the vines.

Bug Death kills comparatively few of the bugs.

As a fungicide.

Blight did not appear as soon nor as badly on plants to which Bug Death was applied at the rate (in 3 applications) of 180 pounds per acre as on untreated vines.

Effect on foliage.

At the rate of 40 pounds per acre no appreciable effect.

At the rate of 100 pounds per acre some of the leaves curled on the edges and finally died.

As a fertilizer.

As its only fertilizing constituent is a little potash it was not tested as a source of plant food.

Its economy.

Because of its high cost and slow application, no one growing any considerable amount of potatoes can afford to use Bug Death. The price of the labor required to apply Bug Death to one acre will buy the materials and spray two acres with Bordeaux and Paris green.

BLACK DEATH AND ENGLISH BUG COMPOUND.

These two compounds have been quite extensively advertised and presumably more or less used in the State. Black Death is apparently Paris green diluted with gypsum to make weight and colored with charcoal. English Bug Compound depends upon white arsenic for whatever value it may have as an insecticide. Gypsum is employed to dilute the white arsenic and to give weight. As both of these goods depend upon arsenic as the

poison, they are no safer to use than any other arsenical insecticide. The English Bug Compound was not used in these experiments. Black Death was applied once on one-fourth acre by the Station at the rate of 40 pounds per acre and it had no appreciable effect on the bugs.

Each of these mixtures are sold, considering their composition, at very high prices and are uncertain and expensive insecticides. If English Bug Compound does not burn foliage, it is only because the manufacturers have used largely of the cheaper plaster, and sparingly of the more expensive white arsenic.

PRACTICAL CONCLUSIONS.

In fighting the Colorado potato beetle no adequate substitute for arsenical poisons has yet been found and there is little hope that any will be found. The efforts are now limited to finding cheaper or more effective compounds of arsenic than Paris green.

The arsenical insecticides are best applied with water in the form of a fine spray as soon as the slugs appear. Unless applied in connection with Bordeaux mixture it is safest to use lime with all arsenical compounds. The applications should be repeated as often as necessary.

Some of the cheaper arsenoids were in these experiments as effective as Paris green. There is no reason for using them or Paragrene in place of Paris green unless they can be had at a lower price.

Lead arsenate is the most satisfactory of the insecticides used by the Station. It is apparently slower in action than the copper compounds of arsenic, but it can be more evenly applied and it adheres firmly to the foliage without burning.

DIRECTIONS FOR SPRAYING.

On application the following special publications of the Station will be mailed free:

Condensed Directions for Spraying the Potato.

Condensed Directions for Spraying Apples.

How to Fight Cucumber Enemies.